Over the years, much of TRL’s work on highway structures has been implemented in UK design standards and advice notes. The knowledge gained in this area is now being transferred to other sectors and to more projects overseas.

See pages 4-5.
Powering the Tube

Over recent years, TRL has broadened its engagement with the rail industry, focusing on the cross-application of knowledge from other transport sectors. One area which could potentially offer significant benefits in the rail sector, is the adoption of alternative energy technologies such as those which have been developing rapidly in the automotive sector, leading to the rise of ultra low carbon vehicles.

TRL has recently been awarded a contract with Tube Lines that combines both these areas of capability. The project will provide a state of the art review of existing and emerging energy storage and power delivery technologies. It will also inform Tube Lines' future planning and investment decisions.

Tube Lines is responsible for both maintenance and upgrade work on London's Jubilee, Northern and Piccadilly lines, for track, signalling, stations, rolling stock and other assets. Recent incidents associated with the operational performance of battery systems on tube trains, has prompted a desire to consider alternative technologies which could offer improved reliability and performance to the network.

TRL's brief is to consider a wide variety of potential solutions without preconceptions about the technologies that may or may not be suitable. In particular, we will look at the potential to transfer recent and ongoing developments in energy storage systems in the automotive sector into the tube environment.

Of particular concern to Tube Lines is the performance and reliability of the existing lead-acid battery systems. These provide traction power for engineering trains and auxiliary power for passenger trains. Engineering trains are used for moving people, equipment and materials around during maintenance activities when the line power is off, while the batteries on passenger trains provide auxiliary power for the lighting, heating and communication systems during temporary line circuit outages.

The study will involve a dual approach to identifying and evaluating the different electro-chemical, mechanical and hybrid energy storage and power delivery options, reviewing published literature and engaging with stakeholders. In taking as broad a view as possible of the technologies potentially suitable for Tube Lines, we are keen to hear from any companies or organisations who feel they have something to offer. So, please do let us know if you have a technology that could be powering the tube!

The Forever Open Road

The Forever Open Road programme, last reported in TRL News in October 2009, has continued to gather momentum. The programme, which has been largely led by TRL in association with European partners from the Forum of European Highway Research Laboratories (FEHRL), achieved a number of notable milestones in 2011, including being placed as the core element of FEHRL's Strategic Road Research Programme for 2011 to 2016. This is important because this will feed into European and national research programmes that will shape the future of highway research for the next five years.

TRL is involved in many European projects that support the Forever Open Road, and December last year saw the commencement of INROADS, a European FP7 Programme project, which is being led by TRL on intelligent road studies. The INROADS (Intelligent Renewable Optical Advisory System) project www.fehrl.org/inroads, which has 8 partners from the UK, France, Austria, Spain and Israel will run for three years, and aim to develop self powered LED road studs containing communication and sensor technologies that can be embedded in the pavement. Whilst the project is at an early stage, it is envisaged that there will be a range of safety, operational and environmental benefits, which will be fed back into the Forever Open Road programme.

December also saw the engagement of a range of European stakeholder organisations with the Forever Open Road programme. There was strong support and a general agreement for cooperation on research strategies and programming.

A success story for TRL was a paper on the Forever Open Road being awarded the best UK paper submitted for the World Road Association Congress, and the best paper overall in the Road Design and Construction category. Martin Lamb of TRL was the lead author who presented the paper at the World Road Association Congress in Mexico City in late September 2011.

So what does 2012 have in store? There will be a focus on promoting the Forever Open Road programme to interested parties, who wish to participate. So far, involvement has largely been from TRL and other European highway research bodies. Going forward, the programme will need to engage with, for example, companies that can design and construct prototypes, vehicle manufactures and communications providers. This promotional phase has already started with the release of a video explaining the project, which can be viewed on the programme web site, www.foreveropenroad.eu

Another key area will be working with partners to secure research funding to undertake projects which, like the INROADS project, contribute to the knowledge pool of the programme, and help make it a reality.

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Martin Lamb receiving his prize at the World Road Association Congress
Safer trains

TRL has a long history of safety development and testing in the automotive industry, but what is often overlooked is our track record in the area of rail safety. This has swung sharply into focus with the recent introduction of the GM/RT 2100 standard.

The UK rail industry, (passenger and freight), is currently in a period of change. New government initiatives such as CrossRail, High Speed 2 and the Inter-City Replacement Programme will see a range of new train designs being put into production in the near future. To ensure these innovative and groundbreaking designs maintain the UK’s strong safety record, safety regulations continue to evolve.

GM/RT 2100 covers a wide range of structural and interior safety considerations for train designs; these include every part of the train, passengers or crew members come into contact with. The standard also assesses the safety of other parts of the train, for example, obstacle deflectors, windows and the aerodynamic properties of the train.

Safety regulations are an important part of a train’s life-cycle; from the design, through upgrades and modernisation work to the stock, right up to final decommissioning. The GM/RT 2100 standard is a vital part of ensuring a train conforms to the highest safety standards. TRL is offering expert consultancy and testing services to train manufacturers, rolling stock leasing companies (ROSCOs), train operating companies (TOCs) and component manufacturers (of seat, tables, windows etc). This includes a range of safety design and testing services focused on providing the rolling stock community with the services they require to fulfill their on-going obligations to comply with GM/RT 2100.

TRL’s impact sled facility is capable of testing rail seats, tables and other train interior components to the strict criteria set out in GM/RT 2100. Our impact sled allows us to mount various seat and table configurations on a specially designed sled, testing multiple conditions in a single impact. This flexibility enables us to provide detailed information on new products quickly and cost effectively, helping clients get their products to market swiftly, while controlling development costs and benefiting from our knowledge of safe design principles. Our biomechanics experts will be on-hand throughout the development and testing process to ensure the most up-to-date knowledge on vehicle safety and injury prevention is built into the design.

Testing will be conducted using the Hybrid III RS dummy, a specialist dummy designed to assess rail impacts which, due to the requirements of the GM/RT 2100, is the best tool to assess seat and table safety performance criteria. TRL worked with RSSB and AEA Technology to develop the Hybrid III RS and is the only test facility with access to this unique dummy.

In addition to dynamic testing, GM/RT 2100 allows test houses to assess the safety and structural performance criteria by means of simulation. TRL’s biomechanics experts can provide guidance and assessments in this area, and to support this, TRL is producing a validated Hybrid III RS dummy model for the purpose of simulation and development of tables and seats to the new standard.

While TRL has extensive experience in impact safety, we are also providing human factors guidance to the design of trains. The requirements of GM/RT 2100 and other standards mean designers need to consider:

- Cab design and layout of control/instrument panels
- Warning signals given to the driver
- How easily the train can be evacuated in the event of an emergency
- The usability of crew areas during normal operations

TRL’s knowledge and understanding can assist designers and manufacturers to not only meet safety standards, but to build safety into the whole design of a train without compromising the usability needs of crew and passengers.

We are arranging a number of ‘open’ testing days to give manufacturers, notified bodies and government organisations the opportunity to see some of our work and discuss our future plans in the area. If you would like to attend, please contact Dr Mark Chattington; ‘open’ testing will occur during May and June this year.

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Research and Consultancy

TRL has a long history of research looking at the design, construction, inspection, testing, maintenance and assessment of highway structures; much of which has been implemented in UK design standards and advice notes. Over the last decade we have moved from long-term research programmes to shorter more highly focused research and consultancy projects and there is greater emphasis on the immediate implementation of our findings. We have also transferred knowledge gained on highway structures to other sectors and have undertaken more work overseas, particularly in developing countries.

**Condition Assessment**

Structure owners need accurate information on the condition of their structures to identify and prioritise maintenance needs. Much of this is obtained from visual inspections which rely heavily on the competence of the individual inspectors. We have been working with Atkins on behalf of a consortium of bridge owners to develop a standardised list of competences for bridge inspectors. The work has produced a framework against which would-be inspectors can be trained and assessed. The aim is to introduce a consistent set of standards in the UK and Ireland for anyone wishing to perform bridge inspections.

To further improve inspections, we are undertaking research to develop machine based techniques for the collection of images that can be used to produce 3D representations of structures. As well as increasing the reliability of the inspections, this approach allows changes in condition to be monitored more accurately by comparing inspections from successive years. At present the technique is limited to simple structures but it is planned to develop it for structures with more complex shapes and to automate the image analysis.

![Series of views of a 3-D representation of a structural element](image)

Visual bridge inspections can only detect defects that manifest themselves on the surface but some types of defect such as the corrosion of wires in post-tensioned prestressed concrete structures and cable supported structures, and reinforcement in hinge-joints and half-joints, remain hidden within the structure.

We are currently monitoring a number of post-tensioned and cable supported structures for wire fractures using SoundPrint®, a technique that detects the acoustic energy released as a wire fractures. This technique has been used as part of a management strategy which has given bridge owners confidence that their structures are safe and can remain in service, thereby avoiding unnecessary or premature replacement, with consequent savings in disruption and cost.

As well as monitoring structures for hidden defects, we have been carrying out detailed examinations of the condition of reinforcement at or near joints in specimens removed from half-joint and hinge-joint bridges prior to their demolition. In both cases the objectives are to obtain information on the state of the reinforcement at the joint, to give an indication of the condition of other structures of similar construction, and to advise on improvements to the management strategy for such structures.

**Long-Term Durability of Concrete Structures**

Concrete bridges are subject to various types of environmental attack which cause them to deteriorate. We have undertaken a number of projects, funded by the Highways Agency and industry, to investigate the performance of a range of techniques for improving the durability of concrete structures. These included an investigation of the use of...
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lightweight and recycled concrete aggregates; air entrained concrete; impregnants; corrosion inhibitors and desalination. These projects included the manufacture of specimens for weathering and exposure, and we have continued to monitor these specimens to obtain information on their long-term performance.

Bridge Deck Waterproofing
We have used our expertise on the waterproofing of bridge decks to assist Network Rail develop documentation on the waterproofing of underline bridges. This includes a new document on the preparation of specifications for waterproofing works and a handbook for site staff that explains the fundamentals of waterproofing. A guidance note on the drainage of underline bridges is also being prepared.

Last October, the Japan Society of Civil Engineers and The Calamity Science Institute invited TRL to give presentations in Tokyo, Sapporo and Osaka on the waterproofing of concrete road bridges.

Asset Management
Effective management of highway structures is essential for targeting scarce maintenance resources. In collaboration with Halcrow, we have provided technical support and advice to the Highways Agency since 2003 on the development and administration of their Structures Management Information System (SMIS). SMIS records detailed inventory information about the assets, generates maintenance and inspection schedules and allows inspectors to record defects against individual components. These condition data drive the maintenance process, allowing work to be prioritised and funding to be sought.

However, structures should not be treated in isolation and decisions on the allocation of maintenance budgets need to take account of the condition and maintenance requirements of all assets on the highway network. With the Highways Agency, we have developed a suite of whole life cost software tools for highways assets, including structures, which allow the life cycle costs of different maintenance options to be evaluated. The software allows Agents, and the Highways Agency, to prioritise maintenance schemes by the return on initial investment from savings in whole life maintenance costs.

Developing Countries
Targeting maintenance works at those structures most in need of repair is also important in developing countries where poor infrastructure is a major constraint to economic growth. We have developed and implemented bridge management systems in Malawi and Mauritius, which introduced a system that was appropriate for the bridge types and environments found in those countries, and which would be sustainable in the longer-term.

Our work involved consultation with the road authorities to determine the requirements of the system, the development of procedures for the collection of inventory and condition data for bridges, the training of local staff in the inspection and condition assessment of bridge components, and organising country-wide programmes of bridge inventory and condition surveys. The data collected from these surveys is input to Road Data Manager (RDM), TRL's Pavement and Bridge Management System, which generates a prioritised list of bridges for maintenance.

Structural Testing
TRL has a substantial structural testing capability which includes a large structural testing laboratory with a strong floor. It allows us considerable flexibility in designing testing regimes to meet customer requirements. We are currently planning a programme of static and rolling wheel tests on road plates that could be used to span openings in the road to reduce congestion during road and street works. Recently, we have undertaken a series of tests on specimens that replicated the shear connection on a major railway bridge. The bridge had been damaged by corrosion and physical impacts and the strengthening works require the provision of a longitudinal shear connection to the slab. Other projects include: load testing to failure and creep tests on sustainable urban drainage systems, low energy impacts on bollards to simulate vehicle impacts and load testing of trolley jacks.

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TRL supports the development of sustainable transport in Addis Ababa, Ethiopia

TRL has entered into a partnership agreement with UN-Habitat to support the development of a sustainable, low carbon transport system in Addis Ababa, Ethiopia. The five year project for which UN-Habitat is the executing agency, forms part of a wider GEF funded programme of work, which is also supporting action in Nairobi, Kenya and Kampala, Uganda.

The Ethiopian Ministry of Transport recently adopted a plan to reform public transport and invest in mass rapid transit solutions in Addis Ababa. Apart from ongoing renovation of the bus fleet of the city’s main provider Arbessa, the Ministry aims to implement a network of seven Bus Rapid Transit (BRT) corridors, as well as two Light Rail Transit ones in the next few years.

An inception meeting for the project was held in Addis Ababa, attended by key stakeholders including representatives of relevant local and national government departments, public transport organisations, academics, and consultants in the transport sector.

During the meeting, key outcomes for the work were discussed and finalised to ensure that the project will effectively support the Ministry’s plans for transport reform. As a result of discussions, TRL will be assisting with:

- Development of a sustainable city-wide public transport system supported by the appropriate institutional and financial structures
- Transformation of the existing transport industry
- Improvement to provision for non-motorised transport
- Parking reform
- Wider travel demand management
- Assessment of the potential application of clean technology

TRL has undertaken a number of technical missions to Addis Ababa building strong relationships with Government officials, public transport operators and donors who are supporting transport interventions in the city. The latest mission, undertaken in February 2012, focused on assessing the current level of provision for non-motorised transport (NMT) in the city, particularly along the BRT demonstration corridor.

There is a significant opportunity to ensure that improvements to the provision for non-motorised transport are carried out in parallel with public transport improvements. Doing so will help to ensure resources are used efficiently. Including provision for NMT at the design stage is far more cost-effective than improving provision later.

The data collected during the assessment in February, which was carried out based on the principle of TRL's Pedestrian Environment Review System (PERS), will be used to develop a 'Non-motorised Transport Manual' for Addis Ababa to support the improvement of provision for non-motorised transport across the city. Whilst the manual will focus on provision for pedestrians along the BRT corridors, it will also provide more strategic recommendations for improvements to aid pedestrians across the city.

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Low Emission Zones

TRL has been researching the impacts of pollution from vehicles for more than 40 years, and has been involved in research on Low Emission Zones (LEZs) since assisting with the feasibility studies for the first UK LEZ, the London Low Emission Zone, in 2005. TRL also works on Low Emission Strategy (LES) measures, which can involve a range of options for encouraging take-up of cleaner vehicle technologies or operating practices, and are usually focused on specific locations.

LEZs are areas where access for vehicles is limited based on vehicle emissions criteria. Vehicles are either banned from entering or charged for entering the LEZ when emissions of pollutants are higher than the specified level, which is often based on European vehicle emission standards. For instance, the London Low Emission Zone includes restrictions on lorries, buses and coaches that do not meet the European "Euro IV" emissions standard for particulate matter, as well as restrictions on some lighter vehicles.

The UK government has acknowledged that more action is needed to achieve compliance with EU limits on air pollution, particularly in hotspot locations in cities and urban areas. In the UK, road transport accounts for up to 80 percent of total NOx concentrations in urban areas. A number of UK local authorities are currently looking at whether LEZs or LESs would be effective in their areas.

Warrington Borough Council has commissioned TRL, together with partner TTR (Transport and Travel Research Ltd) to undertake a feasibility study into LEZs and LESs. The project includes extensive engagement with stakeholders in order to work with local decision-makers and interested parties to find options that could have a positive impact on local air quality, as well as being politically and economically acceptable. The TRL/TTR team is working with the Council and with stakeholders to identify and assess a range of options, before selecting those to be examined more closely.

Outputs for these detailed options will include mapped pollution impacts and cost-effectiveness assessment.

Recent TRL research suggests that driving style is increasingly important for vehicle emissions, and that assessment methods in common use may not adequately consider this aspect. TRL and TTR will be taking this into account as they develop realistic options, particularly when looking at LESs.

With increasing pressure on the UK government to achieve EU limits, TRL's Air Quality and Emissions team expects to be busy in the coming months.

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Transport for London

Low emission ZONE
ARCADY 8 is now available to download from www.trlssoftware.co.uk for all pre-purchase license holders. Industry professionals are more than familiar with previous versions of ARCADY and also with PICADY, ARCADY’s counterpart for the analysis of priority intersections. Both tools have now been 'packaged' within the same interface with time saving features that make ARCADY 8 the next generation in transport modelling software.

**ARCADY 8** has changed and its Priority Intersection Module marks a major leap forward in terms of intersection modelling with all new features designed with the engineer in mind. These include:

- Roundabout Bypass Lanes modelling
- Entry Lane Simulation to analyse queue formation
- PICADY in a new and graphical interface
- Roundabout or Priority Intersections in one file
- Simultaneous analysis of multiple time periods and geometric layouts
- Basic and Advanced modes... helping novice users model quicker!

A mixture of presentations and live, interactive demonstrations of ARCADY 8 filled the recent launch day at TRL’s Wokingham offices. Hands-on sessions allowed the delegates to try out the enhancements themselves, although it was the full simulation model that provoked the greatest interest.

The Entry Lane Simulation tool was developed and integrated into ARCADY 8 so that after a roundabout has been setup, which in itself is now an even easier prospect with the new basic mode for novice users, the user can graphically set up individual entry lanes and toggle through destinations to explore various lane configurations. The different visualisations then display how unbalanced queuing can occur and instantly highlights areas of lane starvation.

For TRL’s customers in the US and Canada, included is the American HCM 2010 Roundabout Capacity Model for roundabout analysis. This is the first time that a non-TRL model has been included in its software. ARCADY 8 is now an obvious choice for engineers needing to utilise alternative analysis methods and cover all bases. ARCADY 8 is the only tool to offer full geometric and gap acceptance modelling capability within a single product, Geometric modelling entails the actual layout of the intersection, through the use of tangents, angles and distances.

**ARCADY 8** customers also benefit from AutoTrack CAD Links which are now free, (previously a chargeable extra in **ARCADY 7**). This allows for real-time analysis of a roundabout performance as it is drawn in CAD. So as the user drags a tangent across the screen the values of queue, delay and RFC constantly change as they are updated.

The Priority Intersection Module for analysis of unsignalled intersections represents the next generation of the massively successful PICADY series. PICADY users can now utilise all of the benefits of the new interface and additional modelling features including the running of multiple geometries, time periods and design years from a single model.

Finally, TRL is not forgetting students and graduates just starting out in the transportation world, as a student version of **ARCADY 8** is also available from our Software Online Store. This has full functionality including the new basic mode, set-up wizards, toolbar tours and a Windows Manager for custom views - but only costs £84 for nine months.

**ARCADY 8** is just one example of how TRL Software is continually refining and developing its software products based on sound research and customer feedback.

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Reducing congestion at roadworks in London

It is estimated that congestion caused by utility companies and highway maintenance contractors, different planting techniques being required for narrow longitudinal trenches and for large excavations. The project has also identified the potential for using “Core and Vac” technologies for maintaining below-surface apparatus through small openings.

An 18-month project, jointly funded by TRL and the Department for Transport (DfT), is being undertaken by TRL to investigate techniques for reducing the time that the carriageway is occupied by roadworks. The project is focusing on three main technologies:

- "Rating and bidding" systems to temporarily cover carriageway excavations and free up the road to traffic at peak times
- "Fast to install and remove" temporary backfill materials to fill openings in carriageways for short time periods
- "Rapid-cure" permanent reinstatement materials that will enable the road to be opened to traffic earlier

TRL is working with road plate manufacturers to develop and test new products to be used by utility companies and highway maintenance contractors, different planting techniques being required for narrow longitudinal trenches and for large excavations. The project has also identified the potential for using “Core and Vac” technologies for maintaining below-surface apparatus through small openings.

The full findings of the project will be published at the end of 2012. In the meantime, a series of short advisory documents known as QWRC Notes (Quick Win Innovation to Reduce Congestion) are being produced to encourage the highways industry to use innovative techniques to reduce the duration of roadworks and help them to reduce lane rental costs. The first Notes cover “Core and Vac”, rapid cure materials, and the use of road plates. These and other project findings are freely available on the TRL website.

www.trl.co.uk/reducingcongestionfromhighwayworks

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Social networking and travel behaviour

The internet has changed the way that individuals access and share information. It has been estimated that “social networks and blogs”, account for almost a quarter of time spent online in the UK, and that the average user of Facebook (the social networking site with the largest market share) is a member of 80 community pages, groups, and/or events, and has 130 contacts.

The role of social networking sites in communication and in bringing user and professionally generated content together has attracted the attention of numerous sectors of the economy. Research has indicated that in the UK, for example, companies are devoting a third of their marketing budgets to campaigns on social networks. In this context TRL conducted an internal study to explore the potential for social networking sites to encourage low carbon travel behaviours.

Interestingly, the scientific literature available does not, as yet, identify any robust evaluations of the impact of social networking sites on travel behaviours. The TRL research team sought to develop this evidence base by conducting focus groups and an online survey with social networking users, as well as interviews with developers of social networking sites that could potentially trigger a change in attitudes towards travel behaviours.

The results of the study (TRL Report, PPR 599) were published in March 2012. It suggests that those who seek to communicate low carbon behaviour messages to the general public should adopt strategies that exploit the engagement opportunities provided by social networking sites. It also concludes that there are a number of design considerations that, if built into the development (and continued maintenance) of a social networking site, could increase this impact.

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